



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:

Shinji TAKEDA et al .

Serial No. 09/785,486

Filed: February 20, 2001

For: SEMICONDUCTOR DEVICE
AND PROCESS FOR
FABRICATION THEREOF

) Atty. Docket: TM&K0008

) Confirmation No.: 9092

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) Group Art Unit: 2827

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) Examiner: D. GRAYBILL

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DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

1. I, MASUKO Takashi, state that I am an expert in the field of semiconductor research and development. I received a Master of Science degree in Environmental Science from the University of Tsukuba in March 1992. I worked in the Tsukuba Research Laboratory, Hitachi Chemical Company Ltd. from April 1992. I have worked in Packaging Material Laboratory, Research & Development Center, Hitachi Chemical Company Ltd. since June 1999. I have been engaged in the development of die attach materials since 1992.

2. I have authored or co-authored and published, for example, the following papers.

1. S. Takeda, T. Masuko: Proceedings of the 1997 Electronic Components and Technology Conference (ECTC), pp. 518-524, 1997.

2. S. Takeda, T. Masuko: Proceedings of the 2000 Electronic Components and Technology Conference (ECTC), pp. 1616-1622, 2000.

3. T. Masuko, S. Takeda: Proceedings of the 9th Micro Electronic Symposium (MES), pp. 249-252, 1999.

4. S. Takeda, T. Masuko: Hitachi Chemical Technical Report, No. 24, pp. 25-28, 1995.

3. I am familiar with the above-captioned patent application and understand that certain prior art references were cited against the claims of the application. Specifically, I am familiar with the Morita et al. reference (U.S. Patent 5,406,124).

4. The foregoing experimental results were collected directly by me, or by others under my direct supervision, and that the experiments were performed with my understanding and knowledge.

5. **Experimental Conditions**

The purpose of this experiment was to compare the closest prior art filmy organic die-bonding material ("prior art film") to the filmy organic die-bonding material of the present invention ("novel film"). Specifically, we utilized the film disclosed by Morita et al. (U.S. Patent 5,406,124) as the closest prior art film and compared the adhesion characteristics (peel strength) and the durability (rate of occurrence of reflow cracks) of the prior art film to the novel film.

6. **Prior Art Film**

The prior art film was produced using the method described by Morita as "EXAMPLE 2" (column 15, line 5 to 15). An amount of 36.8g (0.1 mol) of 4,4-bis(3-aminophenoxy)biphenyl and 137.6 g of N,N-dimethylacetamide were introduced into a container equipped with an agitator, a reflux condenser, and a nitrogen introducing pipe. Thereafter, 10.36g (0.0475 mol) of pyromellitic acid dianhydride and 13.97 g (0.0475 mol) of 3,3',4,4'-biphenyltetracarboxylic acid dianhydride were added little by little into the container under nitrogen atmosphere at room temperature. The mixture was agitated for 20 hours at room temperature. This process produced a polyimide acid varnish.

Next, a Base film of 50 μm thickness was coated on both sides with the polyimide varnish

produced by the previous steps. The coated film was then dried at 100°C for 1 hour followed by drying at 310°C for 1 hour. The result was a three-tiered film having a 10 µm thick polyimide layer (Tg230°C) corresponding to the prior art film of Embodiment No. 13 of the Morita reference (See Table in Morita reference).

The Embodiment No. 13 of the Table in the Morita reference, which corresponds to the film produced using the method outlined in Example 2 of the Morita reference, was selected to represent the closest prior art. I believe, based upon my experience in the art, that Embodiments Nos. 1 through 24 compiled in Table 1 of the Morita reference would manifest similar areal peel strengths because these examples exhibit only minor differences in the structure of the original materials, the acid anhydride, and the diamine, used to formulate them.

7. Novel Film

The novel film was produced using the method disclosed in the specification as originally filed (page 19, line 13 to page 20, line 21). An amount of 280 g of organic solvent (N-methylpyrrolidone) was added to 100 g of polyimide, specifically identified as Polyimide F in the specification and made from DBTA (1, 10-(decamethylene)bis(trimellitate anhydride) / BAPP (2,2-bis[4-(4-aminophenoxy)phenyl] propane), in 10 g of epoxy resin. The mixture was stirred thoroughly until the mixed solution was homogeneously dispersed. The product of these steps was a coating varnish.

Next, a carrier film (OPP film; biaxially stretched polypropylene) was coated with the coating varnish of the previous step. The coated carrier film was then heated in a dryer with internal air circulation for 30 minutes at a temperature of 80°C followed by 30 minutes at 150°C. This heating process evaporated the solvent and dried the varnish. After drying, the carrier film was removed and

the resulting novel film obtained had a thickness of 20 μm . This film corresponds to film No. 8, Table 1, of the specification (page 21) of the above captioned application.

8. Evaluation of Films

(1) Evaluation of film adhesiveness

To evaluate film adhesiveness, the prior art and novel films were cut into 5 x 5 mm sized pieces. Each piece of film was then die-bonded to a 42 alloy lead frame at a temperature of 250°C and a pressure of 120gf/mm² maintained for 5 seconds. Each film was subsequently die-bonded to a 5 x 5 mm silicon chip to form the structure (21, 22, 23) illustrated in Figure 2 of the specification. The experiment was repeated under three different die-bonding conditions. Table 1 shows the conditions under which 5 x 5 mm silicon chips were die-bonded to the lead frame.

Peel strength, as defined in the above -captioned application, was measured by a push-pull gauge at a test speed of 0.5 mm/minute and oriented to pull at a 17-degree angle relative to the surface of each chip as it was described in the present invention's specification (page 33, lines 1-16; Figure 2), except that the samples were tested on the lead frame die-bonded to silicon chips via either the prior art film or the novel film respectively. Furthermore, it is noted that each sample was tested at its respective die-bonding temperature for 20 seconds. The results are expressed as the force in kgf per chip required to peel the silicon chip from the lead frame.

Table 1

Die -bonding Condition	Reason for using the condition	Film	Peel strength (kgf/chip)
250°C x 30gf/mm ² x 20 sec	Described in present claims	Morita's film	0.015
		Novel film	>6 (All chips destroyed)
250°C x 4gf/mm ² x 2 sec	Described in present claims	Morita's film	0.00 (No adhesion occurred)
		Novel film	1.15
230°C x 0.6gf/mm ² x 1 sec	Condition of Example 2 No. 7-10 of the present invention	Morita's film	0.00 (No adhesion occurred)
		Novel film	0.55

(2) Evaluation of reflow cracks

As described in section 8, subparagraph (1) supra, we used identical die-bonding conditions when die-bonding films and chips. To evaluate the rate of occurrence of reflow cracks, semiconductor devices were fabricated utilizing either the prior art film or the novel film. The method of fabricating the semiconductor devices is that method disclosed in the specification (page 19, line 25 to page 20, line 21) of the above captioned application, with the exception that the die-bonding was carried out at the conditions specified in Tables I and II of this declaration. After the die-bonding was carried out, the product underwent wire bonding and then molding with an encapsulant material (CEL9000, Hitachi Chemical Co., Ltd.) to form a semiconductor device. Each semiconductor device was then treated in a thermo-hygrostat at 85°C and 85% relative humidity (RH) for 168 hours, and thereafter heated at 240°C for 10 seconds in an infrared reflow furnace.

The rate of occurrence of reflow cracks was determined by molding each semiconductor device with polyester resin, then cutting each device with a diamond cutter to

expose a cross section. Each cross section was observed via a microscope for cracks (referred to as “reflow cracks,” specification, page 2, lines 16-19). The rate (%) of occurrence of reflow cracks is defined by the following expression: rate (%) of occurrence of reflow cracks = (number of occurrence of reflow cracks/number of tests) x 100. The test results are presented in Table 2.

Table 2

Die -bonding Condition	Reason for using the condition	Film	Rate of occurrence of reflow cracks (%)
250°C x 30gf/mm ² x 20 sec	Described in present claims	Morita's film	100
		Novel film	0
250°C x 4gf/mm ² x 2 sec	Described in present claims	Morita's film	100
		Novel film	0
230°C x 0.6gf/mm ² x 1 sec	Condition of Example 2 No. 7-10 of the present invention	Morita's film	100
		Novel film	0

9. Discussion of the Results

The comparative data compiled in Tables 1 and 2 is commensurate in scope with all of the claims because the die-bonding conditions listed in Tables 1 and 2 all fall within the scope of the die-bonding conditions recited in independent claims 17, 19 and 30. Furthermore, each of the tested films in Tables 1 and 2 are made in accordance with the presently claimed invention and include Polyimide F, which was made from DBTA in epoxy resin. Therefore, each of the tested films in Tables 1 and 2 comprise “an organic material selected from the group consisting of epoxy resin and polyimide resin” as recited in independent claims 17, 19 and 30. Lastly, each of the tested films in Table 1 have the property of a “peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher” as recited in claims 17, 19 and 30. In view of these facts, the experimental data compiled in Tables 1 and 2 has been shown to be

commensurate in scope with all of the present claims.

As is clearly shown in Table 1, under each set of die-bonding conditions, the novel film outperformed the areal adhesiveness of Morita's prior art film. Unexpectedly, the areal adhesiveness of the novel film was so great when die-bonded under certain conditions that it could not be fully measured ($kfg > 6$) by the 17-degree peel strength test used in this experiment because the silicon chips would break before the areal adhesion of the novel film would give way.

As is clearly shown in Table 2, under each set of die-bonding conditions, the novel film outperformed Morita's prior art film in an unexpected way. Specifically, while every one of the semiconductor devices made with the prior art film demonstrated reflow cracks, none of the semiconductor devices made with the novel film suffered these defects. This result is plainly not a matter of degree, but is a matter of unexpected superiority.

10. Discussion of Peel Strength.

The peel strength as defined in the present specification, and as used in the claims, was measured using the push-pull gauge oriented to exert a force at an angle of 17 degrees relative to the planar surface of each chip as illustrated in Fig. 2, and as described on page 33, lines 1-16, of the above captioned application. It is clear from the disclosure of the originally filed, above-captioned application, that "peel strength" as used in the specification is a 17-degree peel strength rather than a conventional 90-degree peel strength or a conventional 180-degree peel strength. The "peel strength", as described and defined in the present application, is a unique test that has advantages over conventional peel strength testing methods for the following reasons.

Specifically, a conventional 90-degree peel strength test, (i.e., "Adhesives – Peel test for a flexible-bonded-to-rigid test specimen assembly" shown in Figure 1 of the International Standard ISO

8510-1:1990(E)), would orient the push-pull gauge so as to exert a force at an angle of 90 degrees relative to the planar surface of the test chip. Conventional 90-degree peel strength is typically measured in units of force per unit length (See Figure 2 of International Standard ISO 8510-1:1990(E)), although the Morita et al. reference reports 90-degree peel strength values in terms of force only (See "Resistance against Peeling" values reported in grams in the Table of U.S. Patent 5,406,124).

A conventional 180-degree peel strength test, (i.e., the "Standard Test Method for Peel or Stripping Strength of Adhesive Bonds" shown in Fig. 2, the Annual Book of ASTM Standards, Designation: D 903-98, 1999), orients the push-pull gauge so as to exert a force at an angle of 180 degrees relative to the planar surface of the test chip. Conventional 180-degree peel strength is typically measured in units of force per length of width (See ASTM Standards, Designation: D 903-98, 1999, section 3.2.2).

I believe that those skilled in the art would know that a 90-degree peel strength test evaluates linear areal adhesive strength whereas a 180-degree peel strength test evaluates shear adhesive strength. On the other hand, the 17-degree peel strength test described on page 33, lines 1-16, and Figure 2, of the above captioned application is a test of oblique or diagonal areal adhesive strength.

The peel strength test described on page 33, lines 1-16, and shown in Figure 2, of the above captioned application, is a different and more efficient test than either of the 90degree peel strength test and the 180-degree peel test because the invention's 17-degree peel test provides, in a single test, a measurement related to both linear and shear adhesive peel strength properties. However, because there is generally no linear relationship between linear and shear adhesive peel strengths, there is no known conversion factor for converting between linear and adhesive peel strength values (i.e., 90-degree peel strength values and 180-degree peel strength values, respectively). Likewise, there is no known

conversion factor for converting between the 17-degree peel strength values according to the definition in the specification, which reflect oblique or diagonal areal adhesion strength, collected in accordance with the method described in the present application, and either conventional 90-degree peel strength values or conventional 180-degree peel strength values.

There are several reasons for developing the peel strength test described on page 33, lines 1-16, and in Figure 2, of the above captioned application. First, the 17-degree peel strength test according to the invention is more efficient in that a single test provides information regarding both linear and shear adhesive strength properties by testing oblique or diagonal areal adhesive strength. Second, the invention's peel strength test provides information related to the interaction of linear and shear adhesive strength properties by measuring the adhesive strength when an oblique or diagonal force is applied. This adhesive strength measured when an oblique or diagonal force is applied is an oblique or diagonal areal adhesive strength, which should depend upon linear areal adhesive strength, shear adhesive strength and the interaction of linear and shear adhesive strengths of the films. This information is relevant to the advantages of the presently claimed invention, which endeavors to minimize the occurrence of re flow cracks and the detrimental effects on semiconductor packages caused by reflow cracks (See present specification, page 2, line 16, to page 3, line 19). The peel strength test described and defined in the present application measures the oblique/diagonal areal adhesive strength, which is an indirect measure of reflow cracking. The finding that reflow cracks can be prevented by employing a certain minimum value for the oblique/diagonal areal adhesive strength is a new finding unrelated to previously known, conventional linear and shear adhesive strengths of organic die-bonding films.

Lastly, choosing force per area as the representational units for measurements of areal adhesion strength tested in the above captioned application, using the 17-degree peel strength test,

was done as a matter of convenience. Specifically, the push-pull gauge measures force in kg force units and each test chip had an area of 5 mm x 5 mm. Therefore, reporting oblique/diagonal areal adhesive strength in terms of kg of force per 5 mm x 5 mm chip area was the simplest way to report the measured values. I believe that a person skilled in the art would realize that the 17-degree peel strength test method described and defined in the above captioned application is a unique test, and that our choice of units are acceptable and useful so long as we use them uniformly throughout our comparative testing.

11. Conclusions

I believe the comparative testing compiled in Tables 1 and 2 above reasonably support the following conclusions. First, the data collected in Tables 1 and 2 is commensurate in scope with the presently claimed invention. Second, the oblique/diagonal areal adhesive strength of the films made in accordance with the presently claim invention, as measured by peel strength testing reported in Table 1, is unexpectedly superior to the oblique/diagonal areal adhesive strength of the Morita film representing the closest prior art. Third, the absence of reflow cracking of films made in accordance with the presently claimed invention compared to the presence of reflow cracking of the Morita film representing the prior is another unexpected and superior characteristic of the films of the present invention.

Lastly, I believe that my testimony establishes the rationale for the 17-degree peel strength test described and defined on page 33, lines 1-16, and Figure 2, of the above captioned application. I believe that a person skilled in the art would realize that the 17degree peel strength test, while not a conventional test, provides valuable information regarding oblique/diagonal areal adhesive strength properties of organic die -bonding films in a manner that is suitable for comparative testing.

12. I declare under penalty of perjury that the foregoing is true and correct, that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed by,

Date: 26, Oct., 2004

Takashi Masuko
MASUKO Takashi

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havdalah var of HADALAH

have \(')hav, (h)av, v; in sense 2 before "to" usu 'haf\ vb had \(')had, (h)ad, d\; hav-ing \(')hav-in\; has \(')haz, (h)az, z, s; in sense 2 before "to" usu 'has\ [ME *haven*, fr. OE *habban*; akin to OHG *haben* to have, *hevan* to lift — more at HEAVE] **vi** 1 a : to hold in possession as property **b** : to hold in one's use, service, or affection or at one's disposal <~ your cake and eat it too> **c** : to consist of : CONTAIN **2** : to feel obligation or necessity in regard to <~ to go> **3** : to learn to get along better, as people ~ to in ... society — H. J. Muller **3** : to stand in relationship to <~ enemies> **4** a : to acquire or get possession of : OBTAIN <these shoes are the best to be *had*> **b** : RECEIVE <*had* news> **c** : ACCEPT, SPECIFY : to accept in marriage **d** : to copulate with **5** a : to be marked or characterized by <~ red hair> **b** : EXHIBIT, SHOW <*had* the gall to refuse> **c** : USE, EXERCISE <~ mercy on us> **6** a : to experience esp. by submitting to, undergoing, or suffering <~ a cold> **b** : to carry on : PERFORM, TAKE <~ a look at that cut> <~ a fight> **c** : to entertain in the mind <~ an opinion> **7** a : to cause to be persuasive or forceful means — used with the infinitive without *to* <~ the children stay> **b** : to cause to be <has people around at all times> **8** : ALLOW <we'll ~ no more of that> **9** : to be competent in <has only a little French> **10** a : to hold in a position of disadvantage or certain defeat <we ~ him now> **b** : to take advantage of : TRICK, FOOL <*been had* by a partner> **11** : to be able to exercise : be entitled to <I ~ my rights> **12** : BEGET, BEAR <~ a baby> **13** : to partake of <~ dinner> **14** : BRIBE, SUBORN <*can be had* for a price> ~ *verbal auxiliary* — used with the past participle to form the present perfect, past perfect, or future perfect <*has gone home*> <*had already eaten*> <*will ~ finished dinner by then*>

syn HAVE, HOLD, OWN, POSSESS, ENJOY *shared meaning element* : to keep, control, retain, or experience as one's own — have at \ha-'vat\ : to go at or deal with : ATTACK — have coming : to deserve or merit what one gets, benefits by, or suffers <*he had that coming*> — have done : FINISH, STOP — have done with : to bring to an end : have no further concern with <*let us have done with name-calling*> — have had it **1** : to have had or have done all one is going to be allowed to **2** : to have experienced, endured, or suffered all one can — have it in for \hav-'it-in-far, -fə(r)\ : to intend to do harm to — have it out : to settle a matter of contention by discussion or a fight — have one's eye on **1** a : to look at **b** : to watch constantly and attentively **2** : to have as an objective — have to do with **1** : to deal with <*the story has to do with real people* — Alice M. Jordan> **2** : to have a specified relationship with or effect on <*refused to have anything to do with his own relatives* — Roald Dahl> <*the size of the brain has nothing to do with intelligence* — Ruth Benedict>

2 have \(')hav\ *n* : one that is well-endowed esp. in material wealth **have-lock** \hav-'læk, -lək\ *n* [Sir Henry *Hav-lock*] : a covering attached to a cap to protect the neck from the sun or bad weather **hav-en** \hə-'vən\ *n* [ME, fr. OE *hæfen*; akin to MHG *haben* harbor, OE *hebban* to lift — more at HEAVE] **1** : HARBOR, PORT **2** : a place of safety : ASYLUM — **haven** *vi* **have-not** \hav-'nät, -nät\ *n* : one that is poor esp. in material wealth

haven't \hav-'ənt\ : have not **have on** *vi* **1** : WEAR <*has on a new suit*> **2** : to have plans for <*what do you have on for tomorrow*> **ha-ver** \hə-'vər\ *vi* [origin unknown] chiefly Brit : to hem and haw **ha-vers** \hə-'vəz\ *n pl* [haver] chiefly Scot : NONSENSE, POPPYCOCK **hav-er-sack** \hav-'ər-sək\ *n* [F *havresac*, fr. G *habersack* bag for oats, fr. *haber* oats + *sack* bag] : a bag similar to a knapsack but worn over one shoulder **ha-ver-sian canal** \hə-'vər-zhən-\ *n*, often cap H [Clifton Havers 1702 E physician & anatomist] : any of the small canals through which the blood vessels ramify in bone **haversian system** *n*, often cap H : a haversian canal with the concentrically arranged laminae of bone that surround it **hav-oc** \hav-'ək, -ik\ *n* [ME *havok*, fr. AF, modif. of OF *havot* plunder] **1** : wide and general destruction : DEVASTATION **2** : great confusion and disorder <*several small children can create ~ in a house*> *syn* see RUIN

havoc *vi* **hav-ocked; hav-ock-ing** : to lay waste : DESTROY **haw** \hə\ *n* [ME *hawe*, fr. OE *haga* — more at HEDGE] **1** : a hawthorn berry **2** : HAWTHORN **haw** *n* [origin unknown] : NICTITATING MEMBRANE *esp* : an inflamed nictitating membrane of a domesticated mammal **haw** *vi* [imit.] **1** : to utter the sound represented by *haw* <*hemmed and ~ed before answering*> **2** : EQUIVOCATE <*the administration hemmed and ~ed over the students' demands*> **haw** *interj* — often used to indicate a vocalized pause in speaking **haw** \hə\ *vb* *imper* [origin unknown] — used as a direction to turn to the left; compare GEE ~ *vi* : to turn to the near or left side **Ha-wai-ian** \hə-'wā-yən, -wī-(y)-ən, -wō-yən\ *n* **1** : a native or resident of Hawaii; *esp* : one of Polynesian ancestry **2** : the Polynesian language of the Hawaiians — **Hawaiian** *adj* **Hawaiian guitar** *n* : a usu. electric stringed instrument consisting of a long soundboard and six to eight steel strings that are plucked while being pressed with a movable steel bar **Hawaii time** *n* : the time of the 10th time zone west of Greenwich that includes the Hawaiian islands

haw-finch \hə-'fɪnch\ *n* ['haw] : a Eurasian finch (*Coccothraustes coccothraustes*) with a large heavy bill and short thick neck and the male marked with black, white, and brown **hawk** \hök\ *n* [ME *hawk*, fr. OE *hafoc*; akin to OHG *habuh* hawk, Russ *kobets*, a falcon] **1** : any of numerous diurnal birds of prey belonging to a suborder (Falcones) of the order Falconiformes and including all the smaller members of this group; *esp* : ACCIPITER — compare OWL **2** : a small board or metal sheet with a handle on the underside used to hold mortar **3** : an individual who takes a militant attitude (as in a dispute) and advocates immediate vigorous action; *esp* : a supporter of a war or warlike policy — compare DOVE — **hawk-ish** \hə-'kɪsh\ *adj* —

hawk-ish-ly *adv* — **hawk-ish-ness** *n*

hawk *vi* **1** : to hunt birds by means of a trained hawk **2** : to soar and strike like a hawk ~ *vi* : to hunt on the wing like a hawk **hawk** *vt* [back-formation fr. *hawker*] : to offer for sale by calling out in the street <~ing newspapers>

hawk *vb* [imit.] *vi* : to utter a harsh guttural sound in or as if in trying to clear the throat ~ *vi* : to raise by hawking <~ up phlegm>

hawk *n* : an audible effort to force up phlegm from the throat **hawk-er** \hə-'kər\ *n* : FALCONER

hawker *n* [by folk etymology fr. LG *höker*, fr. MLG *höker*, fr. *höken* to peddle; akin to OE *heah* high] : one that hawks wares **Hawk-eye** \hə-'ki\ *n* : a native or resident of Iowa — used as a nickname

hawk-moth \hök-'mōth\ *n* : any of numerous rather large stout-bodied moths (family Sphingidae) with a long proboscis which at rest is kept coiled, long strong narrow fore wings more or less pointed at the ends, and small hind wings — called also *sphinx* **hawks-bill** \höks-'bil\ *n* : a carnivorous sea turtle (*Eretmochelys imbricata*) whose shell yields a valuable tortoiseshell

hawk-weed \hə-'kwəd\ *n* : any of several composite plants (as of the genera *Hieracium*, *Picris*, and *Erechtites*) usu. having flower heads with red or orange rays

hawse \höz\ *n* [ME *halse*, fr. ON *hals* neck, *hawse* — more at COLLAR] **1** a : HAWSEHOLE **b** : the part of a ship's bow that contains the hawseholes **2** : the arrangement of the anchor cables of a ship when both a port and starboard anchor are used **3** : the distance between a ship's bow and her anchor

hawse-hole \höl\ *n* : a hole in the bow of a ship through which a cable passes

haw-ser \hə-'zər\ *n* [ME, fr. AF *haucour*, fr. MF *haucier* to hoist, fr. (assumed) VL *aliare*, fr. L *altius* high — more at OLD] : a large rope for towing, mooring, or securing a ship **hawser bend** *n* : a method of joining the ends of two heavy ropes by means of seizings

haw-ser-laid \hə-'zər-'lād\ *adj* : CABLE-LAID

haw-thorn \hə-'thō(r)n\ *n* [ME *hawethorn*, fr. OE *hagathorn*, fr. *haga* hawthorn + *thorn* — more at HEDGE] : any of a genus (*Crataegus*) of spring-flowering spiny shrubs (as the European *C. oxyacantha* and the American *C. coccinea*) of the rose family with glossy and often lobed leaves, white or pink fragrant flowers, and small red fruits

Haw-thorne effect \hə-'thō(r)n-\ *n* [fr. the Hawthorne Works of the Western Electric Co., Cicero, Ill., where its existence was established by experiment] : the stimulation to output or accomplishment (as in an industrial or educational methods study) that results from the mere fact of being under concerned observation

hay \hā\ *n* [ME *hey*, fr. OE *hieg*; akin to OHG *hewi* hay, OE *hēawan* to hew] **1** : herbage and esp. grass mowed and cured for fodder **2** : REWARD **3** slang : BED **4** : a small sum of money <a saving of ... \$14 million is not ~ — H.C. Schonberg>

hay *vi* : to cut, cure, and store for hay ~ *vi* : to feed with hay **hay-cock** \hā-'kāk\ *n* : a somewhat rounded conical pile of hay **hay-er** \hā-'ər, -'et(r)\ *n* : one that hays

hay fever *n* : an acute allergic nasal catarrh and conjunctivitis; *esp* : POLLINOSIS

hay-fork \hā-'fō(r)k\ *n* : a fork that is mechanically operated or held in the hand and that is used for loading or unloading hay **hay-lage** \hā-'lij\ *n* [hay + silage] : a stored forage that is essentially a grass silage wilted to 35 to 50 percent moisture

hay-loft \hā-'lōft\ *n* : a loft esp. for storing hay

hay-mak-er \mā-'kər\ *n* **1** : HAYER **2** : a powerful blow

hay-mow \mā\ *n* : a mow esp. of or for hay

hay-rack \rak\ *n* **1** : a frame mounted on the running gear of a wagon and used esp. in hauling hay or straw; also : a wagon equipped with a hayrack **2** : a feeding rack that holds hay for livestock

hay-rick \rik\ *n* : a relatively large sometimes thatched outdoor pile of hay : HAYSTACK

hay-ride \rid\ *n* : a pleasure ride usu. at night by a group in a wagon, sleigh, or open truck partly filled with straw or hay

hay-seed \hā-'sēd\ *n pl* hayseed or hayseeds **1** a : seed shattered from hay **b** : clinging bits of straw or chaff from hay **2 pl hayseeds : BUMPKIN, YOKEL**

hay-stack \stāk\ *n* : a stack of hay

hay-wire \wī-'ə(r)\ *adj* [fr. the use of baling wire for makeshift repairs] **1** : hastily or shoddily made **2** : being out of order — often used with *go* <*the radio went ~*> **3** : emotionally or mentally upset : CRAZY — often used with *go* <*went completely ~ after the accident*>

ha-zan \kə-'zän, 'küz-'n\ *n pl* ha-za-nim \kə-'zän-əm\ [LHeb *hazzān*] **1** : an official of a Jewish synagogue or community of the talmudic period **2** : CANTOR **2**

haz-ard \haz-'ərd\ *n* [ME, fr. MF *hasard*, fr. Ar *az-zahr* the die] **1** : a game of chance like craps played with two dice **2** : a source of danger **3** a : CHANCE **b** : a chance event : ACCIDENT **4 obs** : STAKE **5** : a golf-course obstacle — at hazard : at stake

hazard *vi* : VENTURE, RISK <~ a guess>

haz-ard-ous \haz-'ərd-əs\ *adj* **1** : depending on hazard or chance **2** : involving or exposing one to risk (as of loss or harm) <a ~ occupation> <*handling ~ materials*> *syn* see DANGEROUS — **haz-ard-ous-ly** *adv* — **haz-ard-ous-ness** *n*

haze \hāz\ *vb* **hazed; haz-ing** [prob. back-formation fr. *hazy*] *vi* : to become hazy or cloudy ~ *vi* : to make hazy, dull, or cloudy

haze *n* [prob. back-formation fr. *hazy*] **1** a : fine dust, smoke, or light vapor causing lack of transparency of the air **b** : a cloudy appearance in a transparent liquid or solid; also : a dullness of finish (as on furniture) **2** : vagueness of mind or mental perception

syn HAZE, FOG, MIST, SMOG *shared meaning element* : an atmospheric condition that deprives the air of its transparency

haze *vi* **hazed; haz-ing** [origin unknown] **1** a : to harass by exacting unnecessary or disagreeable work **b** : to harass by banter, ridicule, or criticism **2** : to haze by way of initiation <~ the

